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No. XV.

LEVELLING INSTRUMENT.

The GOLD VULCAN MEDAL was this session presented to Mr. GEORGE EDWARDS, of Lynn, Norfolk, for his Klinograph or Levelling Instrument; drawings of which are in the Society's repository.

SIR, Lynn, April 25, 1826.

I AM desirous of submitting to the approbation of the Society for the encouragement of Arts, Manufactures, and Commerce, a machine which I have invented for taking levels on an entirely new principle, the chief novelty and advantage of which consists in its drawing on paper the section of the ground over which it is moved, to a scale, in which the scale of heights may be equal to that of lengths, or the scale of heights may be greater, so as to show more apparently the inequalities of the surface. But as it would be difficult to convey a correct idea of the machine by drawings and descriptions, if it is thought worthy of the notice of the Society, I will send it up to London as soon as I am informed of their wish to that effect. And as its construction is such as to require taking to pieces for packing, I shall be happy to come to London myself to put it together, and if the committee could inspect it whilst I am in town, I should be able to explain its mode of operation, which perhaps might not otherwise be clearly understood.

I am, Sir,
&c. &c. &c.
GEORGE EDWARDS.

A. Aikin, Esq.
Secretary, &c. &c.

Description of a Klinograph, or Levelling Instrument.

The object of this machine is, by driving it before you, to obtain a section on paper of the ground passed over, so as to show, at one view, the inequalities of the surface, and by applying a scale, to ascertain the real elevation of any particular spot. In describing the construction of this machine, of which plate X. is a perspective view, it will be well first to observe its general principle, and afterwards enter into the detailed parts.

The line representing the section of the ground passed over, is described by the revolution of a dotting-wheel of steel, about one inch in diameter, the periphery of which is formed into small sharp teeth, which leave a dotted line, as it is made to revolve on paper strained over a drawing-board. The axis of this wheel is so connected to the machine, that as the latter moves forward on the road, the dotting-wheel revolves on the paper very slowly, leaving a dotted track behind it, the length of which is in exact proportion to the distance passed over by the machine. But the principal object is to give the right direction to the dotting-wheel. This is effected by its being connected with a heavy pendulum, which always hangs perpendicularly, whatever be the position of the machine; so that when the machine is out of level, owing to the inequalities of the ground, the plane of the dotting-wheel is made to vary in an equal degree from the horizontal line of the paper; and by the combination of these means, the dotting-wheel describes a section exactly proportionate to the length as well as to the vertical elevation and depression of the ground passed over. Thus it appears that the formation of the section line by this machine is dependent upon two motions influencing the dotting-wheel, namely, the rotatory motion, and the direction given to it.

I now proceed to explain the construction of the parts for each purpose, as shown in plate X., which is a perspective view of the instrument; and in plate XI., in which fig. 1 is a plan of the instrument; fig. 2 a side view of the sliding rods, &c., that communicate the motions of the perambulating wheel and of the pendulum to the dotting-wheel; fig. 3 a view from below of the dotting-wheel, showing the situation of the sliding bars, &c. when in an oblique position, the parts being the same as those seen in the right hand end of fig. 2. Fig. 4 a plan or bird's eye view of fig. 2, together with a section of the quadrant and pendulum-rod. Fig. 5, a section of the machine a little within the hind wheels, as shown by the dotted line in fig. 1, projected from the left hand end of fig. 4; *m'* an arm carrying a friction roller to support the arm *l*, and traversing on the bed *r'*, fig. 4.

On the axis of one of the wheels *a* of the machine (which may be called the perambulatory wheel, see plates X. and XI. figs. 1 and 2, and is about two feet eight inches in diameter) a single threaded screw *a* is cut, this drives a wheel *b* of forty-two teeth, a spindle from this wheel is carried up to the body of the machine, and on the upper end of it is fixed the bevel-wheel *c*, this drives another bevel-wheel *d* of equal diameter, which can be put into gear, when the machine is in use, by the lever *e*, or by the same means may be kept out when the machine is only travelling. At the farther end of this horizontal spindle is fixed a bevel-wheel *f*, which gives motion to an equal bevel *g*, fixed to the short spindle *h*, this spindle terminates in a universal joint *i*, which connects it with the sliding shaft *j*, which is so constructed as to lengthen and shorten as the distance between the universal joints *i* and *k* varies by the motion of the arm *l*. This sliding shaft is connected by the universal joint *k* to the shaft *m*, which is supported at this end, under the bar *n*, by the bearing *o*, and at the other end, where it terminates in another short slide shaft, by the bearing *p* fixed to the revolving arm *q*, and is connected, by a double universal joint, with the dotting-wheel *r*.

Thus by means of the sliding shaft *j*, the rotatory motion is equally conveyed to the dotting-wheel, whether it be on the upper or lower part of the paper; and the bar *n* being jointed to the arm *l* under the cross, allows the dotting-wheel to describe a straight line, or follow the direction given to it, to any part of the paper. The latter part of this description will be better understood by referring to plate XI. fig. 3, where the parts are shown no a larger scale (the same letters being used); and in figs. 2 and 3 will be seen the method of continuing the rotatory motion to the dotting-wheel, when its direction is considerably altered from the horizontal line. The bearing *p* which supports the shaft, turns on the end of a revolving arm *q*, which is moved on a centre *s* by the two connecting rods *t t* fixed to the frame which holds the dotting-wheel; and as this frame is moved by the pendulum, it at the same time carries out the shaft sufficiently to enable the universal joints to work.

Having now described the means whereby the rotatory motion of the perambulating wheel is transferred to the dotting-wheel, before I describe the other motion, that is, the way in which the right direction is given to the dotting-wheel, I must observe that this machine will not only produce a section exactly similar to the form of the ground, but will also describe a distorted section, *i.e.* one having the scale of height much greater than the scale of length, which is generally done in putting on paper a section taken in the ordinary way by the spirit-level, and is very necessary, where the difference of level is but small, to make it more apparent. My machine, as represented in the plans, is adapted for magnifying the height by six. Having premised thus far, I proceed with the description (see the figs. already referred to, and figs. 4 and 5); *a′* is the axis of the pendulum (if I may call that a pendulum whose office it is to remain perpendicular); *b′* the weight at the bottom, about ten pounds; to the axis is fixed the sector *c′*, which is connected with the pendulum-rod by the adjusting screw *d′*; the bottom of the sector is turned circularly with two grooves on the inside, for catguts, and it may be considered as a part of a large bevel-wheel, the grooves for catgut at the bottom supplying the place of teeth; by these catguts it gives motion to the wheel *e′* (much in the same manner as motion is given from a drill-bow to a drill). The radius of the wheel *e′* is one sixth of the radius of the sector *c′*, so that when the body of the machine is one degree, for instance, out of the horizontal line, in consequence of the road making that angle with the horizon, the wheel *e′* is moved six degrees of a revolution by the action of the pendulum. On the circumference of the wheel *e′* are fixed, by two screw pins, the connecting rods *f′ f′*, which, as the wheel moves one way or the other, give a correspondent motion to the cross *g′*, which gives an equal motion to the rods *h′ h′*, which are finally connected with the arms of the cross *i′*, which is attached to the frame *k′*, which holds and directs the axis of the dotting-wheel, causing it to turn on the point in contact with the paper, as the body of the machine varies one way or the other from the level; and by means of this construction of the connecting rods the motion of the pendulum is equally communicated to the dotting-wheel, wherever it be on the paper; the combination of these two motions, therefore, produces a section of the ground in which the scale of height is six times the scale of length.

The brasses which support the axis of the pendulum might be fixed at any height on the rods *l′ l′*, so that a part of a wheel of smaller radius may be fixed to the plate of the axis, to give motion to the wheel *e′*, by which means the proportion between the scale of heights and length will be equally altered, and for very steep ascents, by making the wheels *e′* and *c′* of equal diameters, the section may be drawn to the real proportion of height and length; for the same purpose the pendulum rod is so constructed as to be shortened or lengthened as the height of the axis is altered.

v Is a perfectly flat and smooth board for the purpose of pressing on the four springs *n′*, figs. 2 and 4, to keep the dotting-wheel steady on the paper, and is kept at a proper height from the paper by four nuts on the supports *o′ o′*, and is retained in that position by means of two spring catches *p′ p′*, plate X.

w Is a wheel divided into miles and furlongs, moved by a screw on the upright spindle, and may be used or not in levelling.

B Is a steering handle on the same axis as the guide-wheel *u*; from this wheel proceed two bands to the other guide-wheel C, which is in connexion with the frame that carries the fore-wheel D; by moving therefore the handle B, a corresponding direction is given to the fore-wheel D, and consequently to the whole machine.

y Is a box formed in the body of the machine, to contain adjusting tools, turnscrews, &c.

I now proceed to describe the management of the machine when in use, and first of its adjustment. The drawing board is fixed to the machine by two steady pins, and one screw nut x', so that it is easily taken off to put fresh paper upon it; this being done, a horizontal line must be drawn along the paper, which is readily done, by applying a ruler to two small pins, projecting from the frame of the board for that purpose; by means of the tightening pins y' y' the catguts which connect the pendulum with the wheel e' are to be properly strained, the bevel-wheel *d* put in gear, and the screw of the gripe *z* loosened so as to allow the pendulum to act; the dotting-wheel placed on the beginning of the horizontal line, or one parallel to it, the board *v* put on its place, and the guiding-pulley *u* slipped upon its pin; then having marked the place where the machine starts from, it is to be moved forward five or six hundred feet, and returned to the same spot; when, if on examination the line drawn on the paper by the wheel does not terminate upon the line which it began on, the situation of the pendulum with regard to the sector must be changed by the regulating screw d', till, by repeated experiments, it does so end on the line upon which it began. The machine is then adjusted, and by applying the scale to any elevation or depression afterwards indicated by the machine, it will be shown in feet and inches. If the section required is more than the length of the board will contain, as soon as the dotting-wheel arrives at the end of the paper (which in this machine will be at the end of a quarter of a mile), the board *v* must be taken off, and the dotting-wheel returned to the other end, then replacing the board, go on again. Afterwards, by adding up the rise or fall of each line, the difference of level between the two extremes is obtained, and the paper being taken off the board, all the lines may be transferred in succession, by pricking through to a long strip of paper which will exhibit the whole section.

Fig. 6 a side elevation of the dotting-wheel, and of the cross *i'*.

Fig. 7 a side view of the cross *i'*.

Figs. 8 and 9 a side and an end view of the frame *k'* which carries the dotting-wheel. Its spindle passes through a socket in the centre of the crosss *i'*, and is secured in its place by a set-screw.

Figs. 10 and 11 a side and an end view of the dotting-wheel with its axle.

Fig. 12 a side elevation of that part of the plate *n* which is below the cross *i'*, together with the revolving arm *q*, and its bearing *p*, and one of the rods *t* which connect the revolving arm with the frame of the dotting-wheel.

Fig. 13 a view of fig. 12 seen from below. The spindle of the frame *k'*, fig. 8, passes through, and is at liberty to move in the round hole *s'* in the end of the plate *n* previous to entering the socket of the cross *i'*. The small connecting rods *t t* are fixed by one end on the upper part of the frame *k'*, at right angles to the axis of the dotting-wheel, and by their other end on the revolving arm *q*, and thus change the angle of inclination of the dotting-wheel according to the motion of the pendulum.

I cannot conclude this description without mentioning two improvements which I should have made use of, had I had time before I submitted my machine to the approbation of the Society. One consists in putting two wheels before as well as behind; thus I should avoid a considerable source of error in the machine as it is at present, owing to the fore-wheel being affected by the convexity of the road. The other is, instead of paper on a drawing board as at present, I propose using a long slip of stout paper, or paper on canvass, strained upon a roller at each end of the drawing board, and confined laterally in a groove for that purpose; then as soon as the dotting-wheel had travelled from one roller to the other, whilst the paper on one roller is slackened, it should be wound upon the other; by this means the section would be produced in one continued line, and there would be less trouble in shifting the dotting-wheel.

G. E.